Pattern Recognition in Parity and CP Violation Studies at RHIC

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Kharzeev, Pisarski, and Tytgat[1] predict that Parity odd and CP odd bubbles will occur in heavy ion collisions following chiral symmetry restoration. The bubbles, or zones of fluctuating color fields, are a 'late' stage phenomenon. They occur at the time of chemical freezeout, or perhaps after chemical freezeout. They are a consequence of chiral symmetry restoration and the subsequent chiral symmetry breaking as the collision zone cools back down and the quarks and gluons hadronize.

The experimentalist's challenge is to find these bubbles and to confirm their existence.

The dominate characteristic of the bubbles are parallel E and B color fields which are either aligned or anti-aligned. For simulation purposes, we assume that the quarks propagate through the color fields and that they will behave like classical charged particles propagating through a region of classical electromagnetic fields. Further, we assume that the quarks hadronize at the boundary of the bubble and that the resulting pion travels in the direction of the quark from the bubble.

We have built three models to simulate the process and we assume one bubble per event.

The bubble dynamics is assumed to be similar to a disoriented chiral condensate (DCC). In addition, we force the pions from the bubble to interact with the hypothesized E and B fields while inside the bubble. The field strength is sufficient to give the particles a 30, 60, or 90 MeV momentum kick[2].

Figure one illustrates the flow of pions due to the bubble's electric field simulated in our "Broken – 90" model. Every pion has been reduced to a unit vector; π^+ are shown in red and π^- in blue. We propose to find the flow axis, event by event, by summing the pion momenta over all π^+ and subtracting the sum over all π^-. In the figure, Z is the beam axis and X is the projection of the flow axis into the transverse plane.

In figure two, we plot p_y vs p_z for all pions. The Y axis is defined by the cross product of the flow axis and the Z axis on an event by event basis. The π^+ and the π^- peaks show a clear separation in this plane and the diagonal motion of the peaks is the unique signature of CP violation in these data.

[1]Kharzeev, Pisarski, and Tytgat, PRL **81**, 512 (1988).
[2]Kharzeev, private communication.

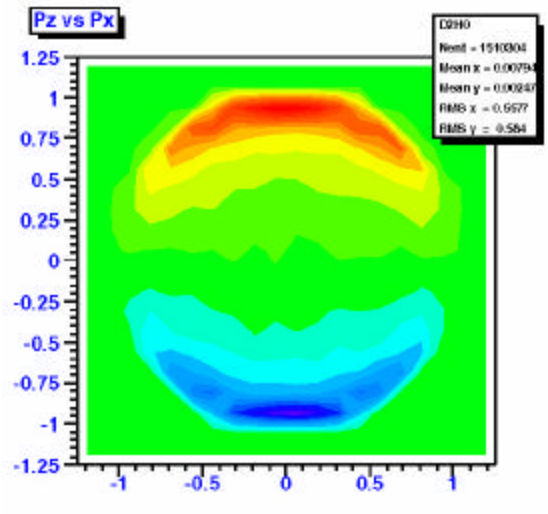

Figure 1: Pion momenta plotted as unit vectors in the Z vs X plane. The charged pions show a net separation in the direction of the E field.

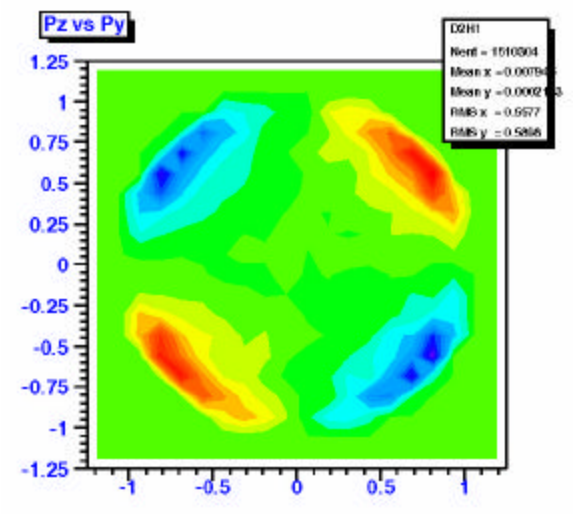

Figure 2: The combined effect of the E and B fields causes the charged pions groups to separate along the diagonal directions.